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Effects of Furrow Diking on Corn Response to Limited and Full Sprinkler Irrigation

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ABSTRACT

Corn (*Zea mays* L.) is a major irrigated crop in the Southern High Plains of the USA that is usually fully irrigated. The trend has been toward center pivot sprinklers equipped with low pressure, closely spaced spray heads that have a large instantaneous application rate that can cause surface water redistribution and/or runoff. This study was conducted to evaluate three surface tillage systems—furrow diking, clean furrows, and flat tillage—on corn yields and yield components during three different growing seasons under two irrigation regimes—full soil water replenishment (FI) and limited irrigation (LI), which was irrigated at the same time as FI but with one-half of the irrigation amount—in a semiarid environment at Bushland, TX. Irrigations were applied with a lateral-move sprinkler system equipped with low-drift spray nozzles. Yields were significantly ($P < 0.05$) affected by year and all treatments. The 1997 and 1999 yields were similar, but the 1998 yields were reduced by a combination of drought and disease. Furrow diking increased corn yields significantly across years and irrigation regimes in this semiarid environment. Irrigation regime almost doubled mean yield from 6.5 Mg ha^{-1} to 12.6 Mg ha^{-1} for the LI and FI regimes, respectively.

Corn is a major crop grown on the U.S. southern High Plains and has increased significantly in the northern Texas High Plains, where some of the greatest mean county yields (USDA-NASS, 1999) occur in the USA because almost all the corn is produced under full-irrigation regimes. Corn has a large seasonal irrigation requirement (Musick et al., 1990) and a large evapotranspiration (ET) demand (Howell et al., 1997, 1998) in the southern High Plains region, which has dramatically shifted from 90% graded furrow irrigation in 1958 to slightly more than 50% sprinkler (mainly center pivot sprinklers) by 1994 (TWDB, 1996). The change in irrigation technology has reduced water applications and contributed to sustained irrigated production in this region (Musick and Walker, 1987). Center pivot sprinklers, now growing in popularity (Musick et al., 1988), are well suited for irrigation in this region where water is a far more limited resource for irrigated agriculture than land (Splinter, 1976). Center pivot sprinkler irrigation application technologies have changed as well to low-energy, precision application (LEPA) (Lyle and Bordovsky, 1983, 1981) and low-elevation, spray applicators that can have significant water redistribution on the soil surface and runoff because of instantaneous application rates that can exceed infiltration rates (Schneider, 2000; Schneider and Howell, 2000).

Surface tillage systems of various types have been used to provide both temporary detention of sprinkler applied water and rainfall to reduce runoff (Jones and Stewart, 1990). Furrow diking or implanted reservoirs are two commonly used methods. Aarstad and Miller (1973), Oliveira et al. (1987), Kincaid et al. (1990), Kranz and Eisenhauer (1990), Solomon et al. (1994), Mickelson and Schweizer (1987), and Hackwell et al. (1994) evaluated surface tillage systems to reduce sprinkler runoff. Basin tillage (or furrow diking) is an integral component of LEPA (Lyle and Bordovsky, 1981). Reservoir tillage uses a combination chisel with a paddle wheel to implant small reservoirs, but these reservoirs impound about one-half the water volume of furrow dikes (Jones and Stewart, 1990). Basin tillage (or furrow diking) was also developed for rainfall capture in semiarid environments (Lyle and Dixon, 1977; Gerard et al., 1984; Jones and Clark, 1987; Baumhardt et al., 1992, 1993; Wiyo et al., 2000) for dryland crop production. For rainfall capture with dryland systems, positive yield responses have been found in years with storm intensity and/or amounts that would be expected to produce significant runoff amounts; however, it has been reported that furrow diking could lead to reduced yields under higher rainfall because of nutrient leaching (McFarland et al., 1991; Wiyo et al., 2000). For enhanced irrigation retention with LEPA or spray systems, positive yield responses have occurred when the irrigation system has a low to medium irrigation capacity (flow rate per unit land area), which has a corresponding large instantaneous application rate that does not result in significant surface redistribution or runoff.

The objective of this study was to evaluate the effects of surface tillage and irrigation levels on corn yields and yield components in the semiarid environment of the U.S. southern High Plains. The primary hypotheses were that under a full-irrigation regime furrow dikes would improve rainfall capture in above average rainfall seasons, when rains might occur after irrigating with a wet soil, and reduce the irrigation requirement. While under a deficit-irrigation regime, furrow dikes were hypothesized to enhance rainfall capture and increase corn yields under both near-average to above-average rainfall seasons.

MATERIALS AND METHODS

This study was conducted at the USDA-ARS Conservation and Production Research Laboratory at Bushland, TX (lat. 35°11′ N; long. 102°06′ W; 1170 m elevation MSL), during the 1997, 1998, and 1999 growing seasons. The soil at this site is classified as Pullman clay loam (fine, mixed, thermic Torrertic Paleustoll), and the field slopes were 0.3% or less. The soil is described by Unger and Pringle (1981) and Taylor et al.

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Abbreviations: FI, full irrigation; LI, limited irrigation; FD, furrow diked; FT, flat tillage; BT, bedded tillage; DOY, day of year; ET, evapotranspiration; LEPA, low energy, precision application irrigation; LDN, low drift nozzles.

Table 1. Cultural operations and dates and agronomic information for the three growing seasons. Dates in parenthesis are for the limited irrigated treatments.

Operation or Parameter	1997	1998	1999
N applied	19 Mar. 270 kg (N) ha^{-1}	3 Apr. 260 kg (N) ha^{-1}	7 Apr. 290 kg (N) ha^{-1}
P applied	19 Mar. 112 kg (P) ha^{-1}		
Sweep plowed field	23 Apr.	21 Apr.	7 Apr.
Installed plot borders	5 May	22 Apr.	19 Apr.
Planted corn (variety)	6 May (PIO-3225)†	23 Apr. (PIO-3225)	21 Apr. (PIO-3162)
Soil sampled (water)	6 May	23 Apr.	21 Apr.
Pre-emergence herbicide		30 Apr. 2.2 kg ha^{-1} Atrazine‡ 1.1 kg ha^{-1} Metolachlor¶	21 Apr. 2.2 kg ha^{-1} Atrazine‡
Corn emergence	15 May	7 May	4 May
Post emergence herbicide	0.9 kg ha^{-1} Atrazine‡		
Neutron tube installation	28 May	2 June	18 May
Cultivation and dike installation	6 June	2 June	2 June
Tassel emergence	16 July (18 July)	12 July (15 July)	12 July (14 July)
Insecticide application	3 Aug. 0.04 kg ha^{-1} Bifenthrin§ 3 Aug. 0.5 L ha^{-1} Dimethoate#	18 July 0.04 kg ha^{-1} Bifenthrin§ 3 Aug. 0.5 L ha^{-1} Dimethoate#	8 Aug. 0.04 kg ha^{-1} Bifenthrin§
Harvested plots	3 Oct.	16 Sept. (10 Sept.)	8 Sept. (7 Sept.)
Soil sampled (water)	10 Oct.	8 Oct.	4 Oct.

† Pioneer Hi-Bred International, Inc.
‡ (2-chloro-4-ethylamino-6-isopropylmino-S-trazine).
§ (2 methyl[1,1′-biphenyl]-3-yl) methyl 3-(2-chloro-3,3,3-trifluoro-1-propenyl)-2,2-dimethyl-cyclopropanecarboxylate.
¶ 2-chloro-*N*-(2-ethyl-6-methylphenyl)-*N*-(2-methoxy-1-methylethyl) acetamide.
# *O,O*-dimethyl *S*-[(methylcarbamoyl)methyl] (phosphorodithioate).

(1963) as slowly permeable because of a dense B21t horizon about 0.15 to 0.4 m below the surface. The plant available water holding capacity within the top 2.0 m of the profile is approximately 250 mm, but corn cannot fully exploit and extract the soil water below about 1.5 m because a calcareous layer limits significant rooting and water extraction below this depth (Tolk et al., 1998). This soil is common to more than 1.2 million ha of land in this region and about 33% of the sprinkler irrigated area in the Texas High Plains (Musick et al., 1988).

The fertilizer applications were based on standard soil fertility analyses and were deemed sufficient to eliminate the possibility of a nutrient limitation for the fully irrigated water regime (Table 1). The plots were each 13.7 m wide (E-W) (18 rows spaced 0.75 m apart) and approximately 40 m long (N-S). Each plot was bordered diked on the E and W sides, and a 4.6-m-wide guard plot separated water treatments in the E-W direction to permit manual system speed changes to adjust the application amount. All cultural operations were preformed with standard 6-row farm equipment (Table 1). Sowing densities achieved mean field plant densities of 8 plants m^{-2} each year at harvest. Plots were seeded on previously summer fallowed areas each year.

The irrigation system was a three-span lateral move sprinkler system with a pressurized water supply via a 100-mm-ID hard hose from hydrants (Valmont Industries, Inc., Valley, NE)[1]. Operating pressures at the pull-tower were typically 140 kPa. Low-drift nozzle (LDN) spray heads with double spray plates with 42 kPa pressure regulators (Senninger model PMR-MF, Senninger Irrigation, Inc., Orlando, FL) and 8.3 mm (#21) nozzles rated to flow at 0.465 L s^{-1} were spaced 1.5 m apart and about 1.8 m above the ground with 0.9-kg polyethylene weights to reduce swaying of the drops in the wind. The nozzle flow rates were selected to simulate the outer span of a 400-m-long center pivot sprinkler with an irrigation capacity of approximately 8 mm d^{-1} (0.93 L ha^{-1} s^{-1}).

The experimental design was a variation of a split-block design (Little and Hills, 1978) with three replications. The irrigation regimes were strips across each main treatment surface tillage regime applied after planting—soil surface nearly flat (FT), bed tillage (BT), and beds with furrow dikes (FD) installed with a trip-roll diker (Bigham Brothers, Inc., Lubbock, TX). Dike spacing varied but averaged 1.8 to 2.0 m. The tillage plots and rows were perpendicular to the irrigation system travel path, and each plot length was an entire span length with the next tower wheels running north of plot berm to prevent N-S water runon onto a plot. An E-W waterway permitted any irrigation or rainfall runoff to flow down slope without entering the plots on the next span to the south. The experimental area was rotated each season to a previously summer-fallowed field area.

The irrigation treatments were based on soil water depletion replenishment. The fully irrigated treatment (FI) received near full soil water replacement for the depletion in the upper 1.5 m of the soil profile while allowing 25 to 30 mm of water holding capacity for rainfall storage. Plot runoff was not measured, but it never occurred from the LI treatments and was negligible for the FI treatments with dikes. Irrigation control was based on biweekly to weekly soil water measurements using neutron scattering (model 503DR, Campbell Pacific Nuclear Corp., Martinez, CA). The neutron probe was calibrated to the Pullman soil (Evett and Steiner, 1995), and 30-s readings were taken from 0.2 to 2.4 m deep in 0.2-m increments. One neutron tube was installed in each replication of the furrow diked, fully irrigated (FD, FI) plots. The limited irrigation treatment (LI) was irrigated at the same time as the FI plots, but the system speed was doubled to apply one-half the amount that the FI treatment received. Each plot was sampled to 1.8 m in 0.30-m increments with a mechanical soil sampler at planting and following harvest and soil water content was determined gravimetrically. Samples from each layer were oven dried at 105°C to determine the soil water content and

[1]The use of trade, firm, or corporation names is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture or the Agricultural Research Service of any product or service to the exclusion of others that may be suitable.

Table 2. Climatic data during the three growing seasons and the 50-yr mean climate data for this location

Month	Tmax†	Tmin‡	Tdew§	2-m wind speed	Solar irradiance	Barometric pressure	Rainfall	ET_o¶
	°C			m s^{-1}	MJ m^{-2} d^{-1}	kPa	mm	mm d^{-1}
				1997				
Apr.	16.1	2.2	3.5	4.89	18.4	88.6	132.1	3.53
May	23.9	10.0	9.9	4.23	23.4	88.9	43.7	5.15
June	29.5	15.1	14.3	4.08	24.6	88.7	29.3	6.44
July	32.2	17.7	15.3	3.95	25.5	89.0	28.6	7.17
Aug.	30.3	16.9	16.6	3.24	21.4	89.2	82.5	5.40
Sept.	28.6	14.8	13.7	3.64	17.5	88.9	26.5	4.92
Oct.	22.0	6.7	6.0	4.60	15.7	88.9	19.1	3.89
				1998				
Apr.	19.5	2.9	−1.1	4.56	21.9	88.6	8.1	5.11
May	29.3	11.4	4.0	4.17	25.2	88.6	27.6	7.63
June	32.4	14.8	2.8	4.79	28.0	88.6	1.2	9.59
July	34.3	18.6	11.7	3.64	25.3	89.2	26.6	8.12
Aug.	31.2	16.4	14.5	3.23	22.5	89.3	34.6	6.07
Sept.	30.9	15.0	12.2	3.38	19.1	89.0	1.0	5.70
Oct.	21.8	8.1	7.8	4.40	13.8	89.1	196.8	3.61
				1999				
Apr.	20.6	5.9	4.4	4.22	17.2	88.9	87.8	4.63
May	23.6	9.1	9.3	4.25	23.4	88.7	65.9	5.03
June	29.1	15.1	14.8	4.28	25.1	88.9	67.3	6.26
July	31.3	17.9	17.0	3.84	26.0	89.1	99.4	6.61
Aug.	32.1	17.3	16.1	3.35	23.1	89.2	37.8	6.27
Sept.	26.0	12.7	11.3	4.16	18.0	89.1	63.7	4.86
Oct.	23.4	5.9	3.5	4.81	17.3	89.3	5.1	4.91
				59-Year Historical Mean				
Apr.	20.9	3.6					27.7	
May	25.1	9.4					67.6	
June	29.9	14.8					75.2	
July	32.3	16.9					67.8	
Aug.	30.9	16.3					71.6	
Sept.	27.2	11.8					48.8	
Oct.	21.8	5.1					38.6	

† Air temperature maximum.
‡ Air temperature minimum.
§ Dew point temperature.
¶ Reference grass evapotranspiration.

season profile soil water depletion was computed from the differences between the two sampling dates.

Yield was determined by hand harvesting two 6.56-m-long row sections from differing planter passes for a 10-m^2 sample area. The plants and ears were counted. The ears were removed from the shucks and oven dried at 70°C until no mass change was observed. Then, the grain was shelled from the cob and weighed. Kernel mass was determined from 250 kernel subsamples from each row sample. Row samples were averaged to determine each plot's yield parameters. Grain yields are reported at standard 155 g kg^{-1} water content, and kernel mass is expressed on a dry basis. Yield, yield components, and soil water depletion data were analyzed by means of SAS (Littell et al., 1996) procedures based on PROC MIXED as described in Hunsaker et al. (1996) for a strip-split-plot model (also known as a strip-block layout).

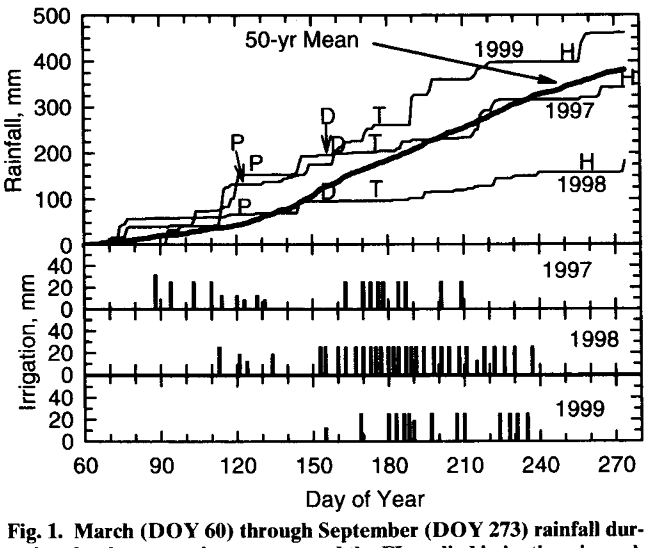

Fig. 1. March (DOY 60) through September (DOY 273) rainfall during the three growing seasons and the FI applied irrigations in each season. The letters P, D, T, and H are the plant, dike install, tassel emergence, and harvest dates for the FI treatments.

RESULTS AND DISCUSSION

The environmental conditions of each season were different and characteristic of the climatic variability in the southern High Plains (Table 2). Figure 1 illustrates the March day of year (DOY) 60 through September (DOY 273) rainfall recorded near the plot area in comparison with the 50-yr mean Bushland rainfall and the FI irrigations applied in each season. Rainfall for March and April are included in Fig. 1 to illustrate simply that corn cannot be established reliably at Bushland without irrigation if sown before 1 May. The 50-yr mean rainfall for the month of April is 28 mm, and in only the 1997 and 1999 seasons could corn be established without irrigation. Both of these seasons had significantly more rainfall in April (477% above-normal in 1997 and 317% above-normal in 1999), before normal corn sowing dates,

Table 3. Irrigations, growing season rainfall, and 1.8-m profile soil water depletion.

Component	1997 FI depth	1997 LI depth	1998 FI depth	1998 LI depth	1999 FI depth	1999 LI depth
	mm					
Irrigation	559	279	749	419	337	174
Rainfall	211	211	84	84	323	323
Soil water depletion						
Diked (FD)	154	153	118	143	45	86
Flat (FT)	166	163	113	136	106	106
Open (BT)	145	190	123	147	105	102

than would be expected on average. The 1997 season had wetter than normal April, but the May through September months had only 64% of normal rainfall. In 1997, only one day had a rainfall amount greater than 20 mm after furrow dike installation, and it was 24.4 mm, occurring on DOY 146 (Fig. 1). The 1998 season was the driest summer in Bushland's history until a large rain occurred in late October after harvest. The April rainfall was 29% of normal, and the May through September rainfall was 28% of normal. No significant rainfall occurred in 1998 after furrow dike installation (Fig. 1). Rainfall in 1999 was more evenly distributed, except for August and October when rainfall was below normal, but the growing season rainfall (May through September) was only 1% above normal. In 1998, two significant rainfall events that exceeded 20 mm occurred on DOY (59.8 mm) and DOY 257 (38.6 mm) (Fig. 1). Growing season temperatures and grass reference ET were similar in 1997 and 1999. The advective and drier summer of 1998 was especially noticeable in the lower dew point temperatures and larger grass reference ET values in May and June coupled with the smaller rainfall.

Soil Water

Total applied water (sum of irrigation plus rainfall) to FI was least in 1999 at 660 mm and most in 1998 at 833 mm (Table 3). Soil water depletion (Table 3) did not vary significantly among the treatments according to the analysis of variance in 1997, but the differences between FI and LI were significant ($P < 0.05$) in 1998, and the tillage treatments were slightly different ($P < 0.10$) in 1999. These results are consistent with other dryland studies in semiarid climates (Baumhardt et al., 1992 and 1993; Gerard et al., 1984; Jones and Clark, 1987; and Unger, 1992) that indicate furrow dikes would be more effective during above-normal rainfall seasons. Soil water at harvest (data not shown) was affected ($P < 0.05$) by irrigation in 1997 and 1998, but not in 1999 when soil water at harvest was lower in the FT and BT treatments than in the FD treatment. Figure 2 shows the 2.5-m profile soil water contents for each season. These are generally the driest water contents since measurements were taken the morning before an irrigation or the day before an irrigation. In all years, the soil water contents declined during the growing season from deeper water profile extraction (mainly in the 0.8-m to 1.5-m depths) that could not be replaced by 25-mm applications that are typical for center pivot sprinklers.

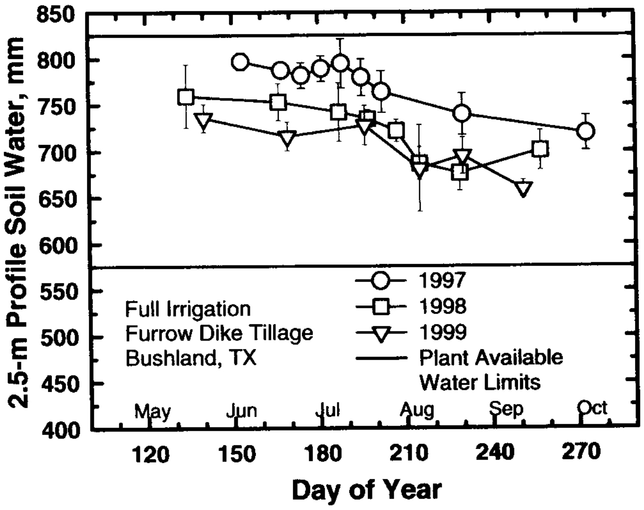

Fig. 2. Soil water in the 2.5-m soil profile for the full irrigation, furrow diked treatment in each year. Error bars are standard deviations.

Irrigations were applied as often as three times per week in order to meet ET demand based on the measured soil water contents and atmospheric data. In 1997, the profile water contents were maintained well; however, in both 1998 and 1999 the initial soil water profiles were drier (Fig. 2) and soil water levels for FI may have induced water deficits that could have reduced grain yields. The possible soil water deficits that were observed in 1998 and 1999, may have caused the reduced mean corn yields of the FI treatments in those years (2.1 Mg ha^{-1} in 1998 and 2.2 Mg ha^{-1} in 1999); however, the mean FI yields of the mean FD treatments had a coefficient of variation less than 0.05 for the three seasons. Tolk et al. (1998) reported less water uptake in the Pullman soil by corn below 1.5 m than other soils. McFarland et al. (1991) reported increased soil water contents with rainfed corn with diking alone or with conservation tillage with or without diking in a below average rainfall year. The high irrigation application rate of the spray system may have led to reduced water storage capacity of FD under the FI and LI regimes because of dike siltation from the walls similar to findings of Coelho et al. (1996), Kranz and Eisenhauer (1990), and Spurgeon et al. (1995).

Grain Yield and Yield Components

The grain yield was affected by the growing season, surface tillage and irrigation regimes (Table 4). Grain yields were not different between 1997 and 1999, but they were less in 1998 ($P < 0.01$) because of the drought and a heavy infestation of smut [*Ustilago zeae* (Beckm.) Unger], particularly in the LI treatments. The smut infestation affected up to 75% of the ears in some of the LI plots. Smut was a regional problem that year because of the drought, a high incidence of plant injury from the winds, and certain hybrid lines that had an unusual susceptibility to the disease, like Pioneer 3225 that was used that year. The low yields in the LI treatments in 1998 were responsible for the significant year × irrigation regime interaction (Table 4). FD increased the mean

Table 4. Analysis of variance for grain yield (Mg ha^{-1}) at 15.5 g kg^{-1} water content and main factor means.

Source	df	F	$P > F$
Year	2	92.94	0.0001
Tillage	2	10.08	0.0001
Irrigation	1	307.96	0.0065
Year × Tillage	4	1.49	0.2355
Year × Irrigation	2	62.63	0.0001
Tillage × Irrigation	2	1.14	0.3665
Year × Tillage × Irrigation	4	1.30	0.2978
Main Factors		Yield	
Year		Mg ha^{-1}	
1997		11.22a†	
1998		6.87b	
1999		10.48a	
Tillage			
FD		10.61a	
FT		9.21b	
BT		8.76b	
Irrigation			
FI		12.59a	
LI		6.46b	

† Means within a factor followed by different letters are statistically different ($P < 0.05$).

Table 5. Grain yields, kernel mass, and kernel numbers for 1997, 1998, and 1999 growing seasons for corn as affected by treatments.

Treatment	Grain yield†	Kernel mass†	Kernel number
	Mg ha^{-1}	mg kernel^{-1}	kernels m^{-2}
1997			
Full irrigation			
FD	14.49a‡	273a	4576a
FT	13.74a	260ab	4408a
BT	13.74a	260ab	4546a
Limited irrigation			
FD	8.86b	242c	3149b
FT	8.62b	249bc	2991b
BT	7.88b	245c	2760b
$LSD_{0.05}$	1.81	13	574
1998			
Full irrigation			
FD	14.19a	269a	4536a
FT	11.75ab	259ab	3891ab
BT	10.01b	254b	3382b
Limited irrigation			
FD	2.30c	269a	736c
FT	1.50c	259ab	496c
BT	1.47c	254b	497c
$LSD_{0.05}$	2.59	14	746
1999			
Full irrigation			
FD	13.38a	274a	4207a
FT	11.18b	261a	3689b
BT	10.87b	262a	3570b
Limited irrigation			
FD	10.40b	264a	3393b
FT	8.44c	269a	2696c
BT	8.63c	258a	2877c
$LSD_{0.05}$	1.37	16	344

† Grain yield expressed at 155 g kg^{-1} water content wet basis. Kernel mass is expressed on a dry basis.

‡ Means within a year followed by different letters are statistically different ($P < 0.05$).

corn yield by 1.40 Mg ha^{-1}, while mean yields were not different between the FT and BT treatments. The irrigation treatment reduced the mean yield in all years, but the greatest mean separation occurred in 1998.

The LI regime reduced grain yields of all tillage treatments in 1997 and 1998, but the FD treatment improved the LI yield in 1999 (Table 5). In 1997, the tillage treatments did not affect grain yield, but the LI treatments reduced kernel numbers because of a smaller ear size. In 1998 under the FI regime, FD significantly increased grain yield compared with BT mainly by increasing kernel mass and ear size. In 1999, FD significantly increased grain yield in both the FI and LI treatments mainly through increase ear size since ear density was not different among the treatments. The 1999 the FD, FI grain yield was less than the FD, FI grain yields in 1997 and 1998 by almost 1.0 Mg ha^{-1}, and this may have been the result of the lower profile soil water in 1999 (Fig. 2) following the summer drought in 1998. At comparable N fertility, McFarland et al. (1991) did not report a yield benefit for FD of corn or an effect on leaf and grain N levels under rainfed conditions. They did indicate that there was a tendency for FD to reduce yields under high rainfall levels. Our results did not support that tendency under FD and full irrigation regimes or even under LI regimes on the Pullman soil.

Furrow diking treatments did not consistently increase corn yields with the LI regime, as anticipated, but FD did appear more effective in the normal to wetter season in 1999 (Table 5). Unfortunately, the smut damage to the LI treatments in the drought season, 1998, obscured any FD effects on grain yields when we would have expected the greatest benefit on the basis of the findings of McFarland et al. (1991). Schneider and Howell (1998) using FD reported no yield differences between overhead spray (comparable to this study) and LEPA in the sock mode. Their 100 and 50% irrigation mean grain yields were similar to the FI and LI treatment grain yields in 1997 and 1999 in this study. Tolk et al. (1998) reported smaller yields in 1996 for corn that was fully irrigated to meet ET use in rain sheltered lysimeters than we obtained for the FI treatment. They used a lower plant density (6 plants m^{-2}), which may account partially for the lower yields. Their 50% irrigation treatment had comparable yields to our LI treatments in 1997 and 1999.

CONCLUSIONS

Furrow diking of fully and deficient-irrigated corn significantly improved grain yields across three growing seasons and under two irrigation regimes compared with other surface tillage systems. The high irrigation application rates of spray systems may lead to reduced water storage capacity of furrow dikes under conditions like these because of dike erosion, but we did not observe any runoff problems on the FD treatments from either irrigations or storm runoff. During these three seasons, only three large rainfall events (>20 mm) occurred when the furrow dikes were in place. In more normal rainfall growing seasons, limited irrigation of corn (a 50% irrigation reduction) produced grain yields that were only reduced 39% (1997) and 22% (1999) in comparison to a more fully irrigated treatment. The drought season, 1998, clearly indicates the risks associated with not fully irrigating corn in this semiarid environment, though, when an 85% reduction in yield occurred with limited irrigation (a 50% irrigation reduction).

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